MSC-07640

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 16 MISSION

ANOMALY REPORT NO. 6

REACTION CONTROL SYSTEM
HELIUM PRESSURE REGULATOR FILTER FAILURE

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
DECEMBER 1972

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REACTION CONTROL SYSTEM HELIUM PRESSURE REGULATOR FILTER FAILURE

STATEMENT OF ANOMALY

The end caps of two of the four command module reaction control system helium pressure regulator inlet filters were bulged.

SYSTEM DESCRIPTION

The command module reaction control system uses redundant propellant tanks pressurized by redundant helium sources. Interconnection capability is provided to allow either of the helium sources to pressurize all propellant tanks.

The helium is stored in the two tanks at 4150 psi. Each tank has a pressure reduction system (figs. 1 and 2) consisting of a 0.055-inch flow-limiting orifice feeding two pairs of series redundant regulators through pyrotechnically actuated isolation valves. The pyrotechnic valves each contain a 40-micron outlet filter to trap any debris generated during activation. The regulators are provided with 25-micron inlet filters.

DISCUSSION

The command module reaction control system helium pressure regulators were removed, disassembled, and examined as part of the investigation of a regulator leakage problem which occurred on the Apollo 16 lunar module. The command module and lunar module regulators are identical. The lunar module problem is discussed in section of 14.2.4 of the Apollo 16 mission report.

The regulator inlet filter end caps were found bulged 0.005 to 0.070 inch beyond the edge of the weld lip (fig. 3). About 5 percent of the wire strands in one of the filters were broken and the rating of the filter was increased from 25 to 94 microns. The broken strands were warp wires (fig. 4) and the breaks were ductile separations.

At system activation, the pyrotechnic isolation valves are operated in pairs by two different relay circuits (fig. 1). Differences in relay pull-in times and valve actuation times may result in 2 to 3 milliseconds difference between valve opening times.

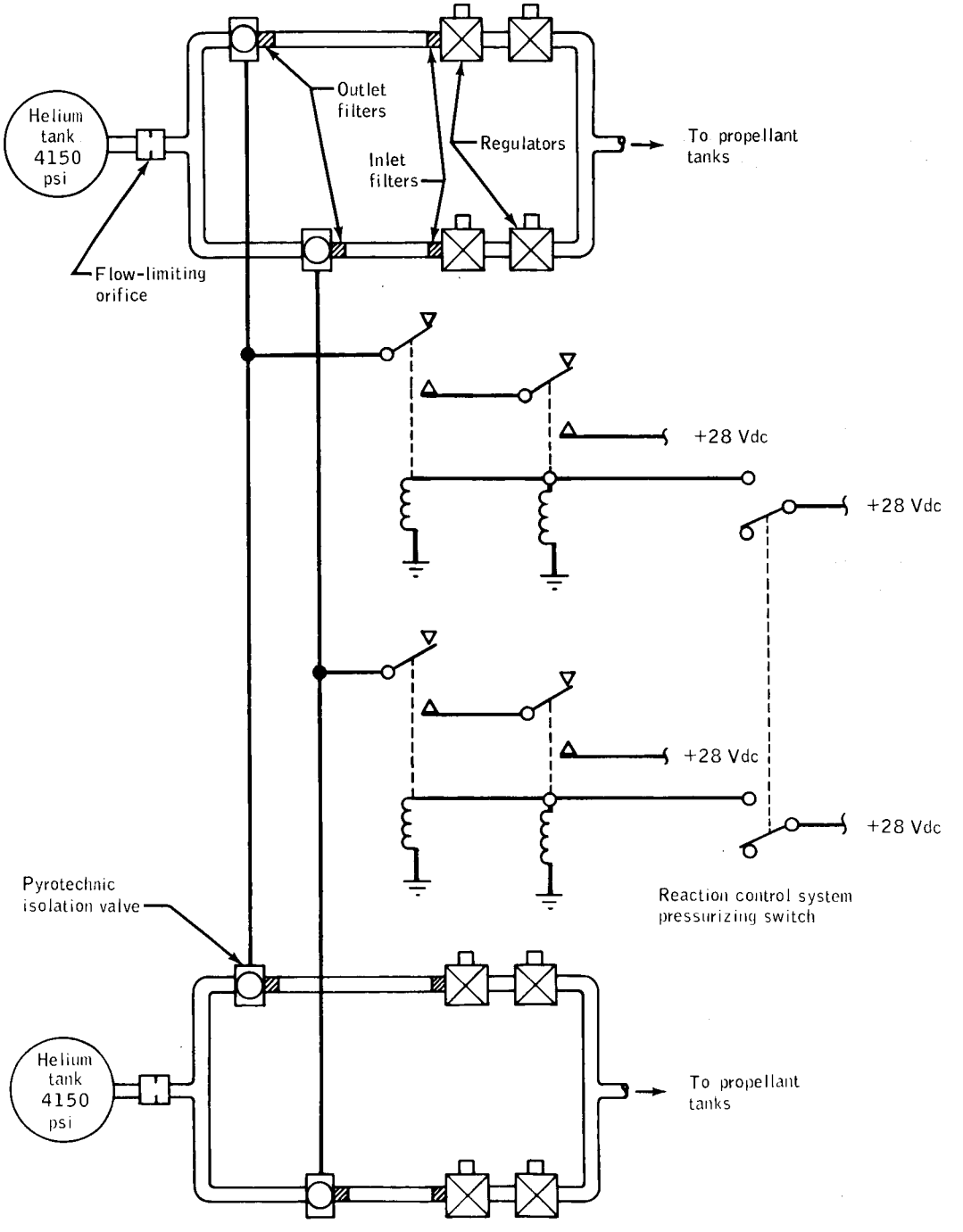


Figure 1.- Helium pressurization for reaction control system.

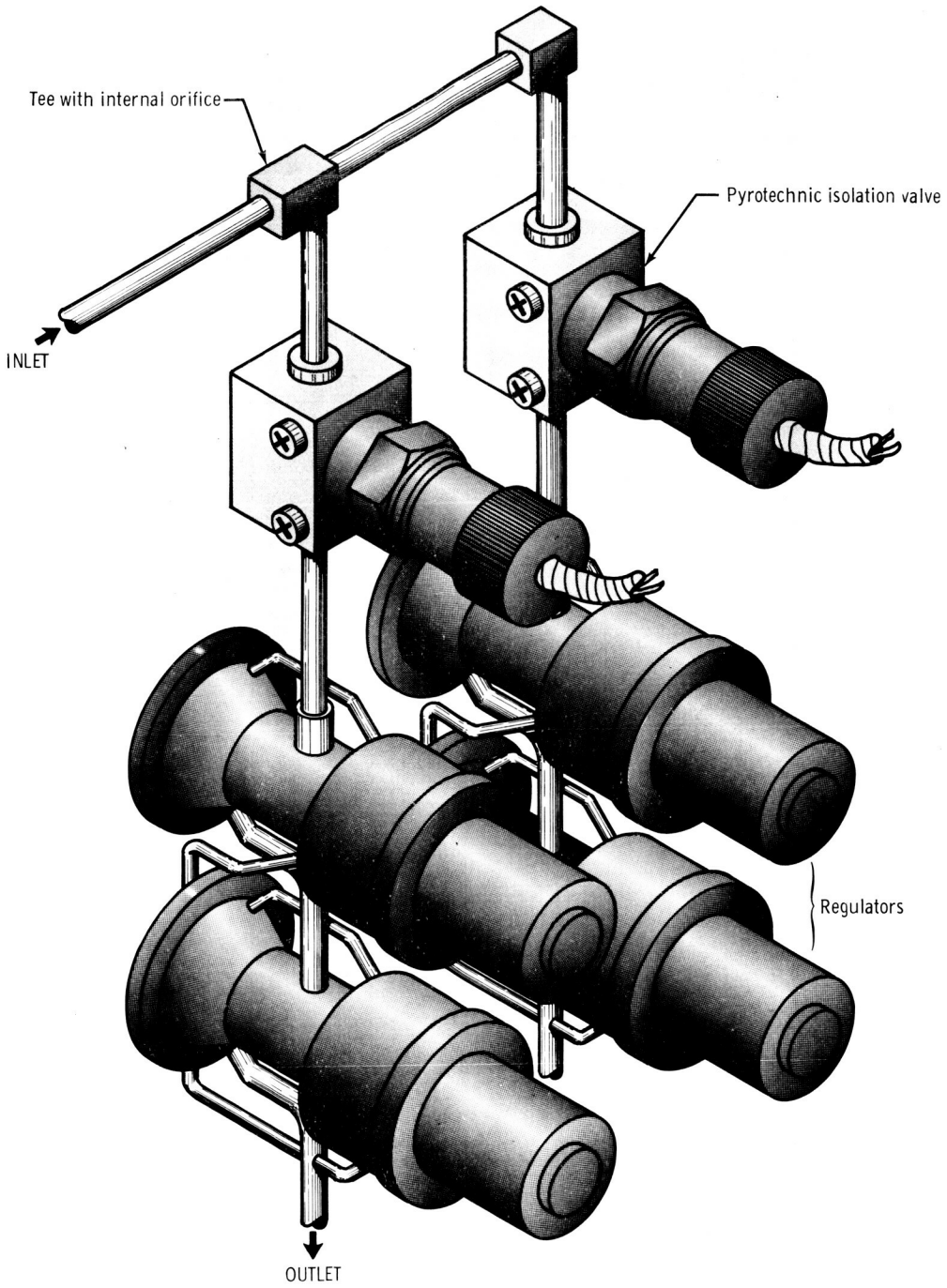
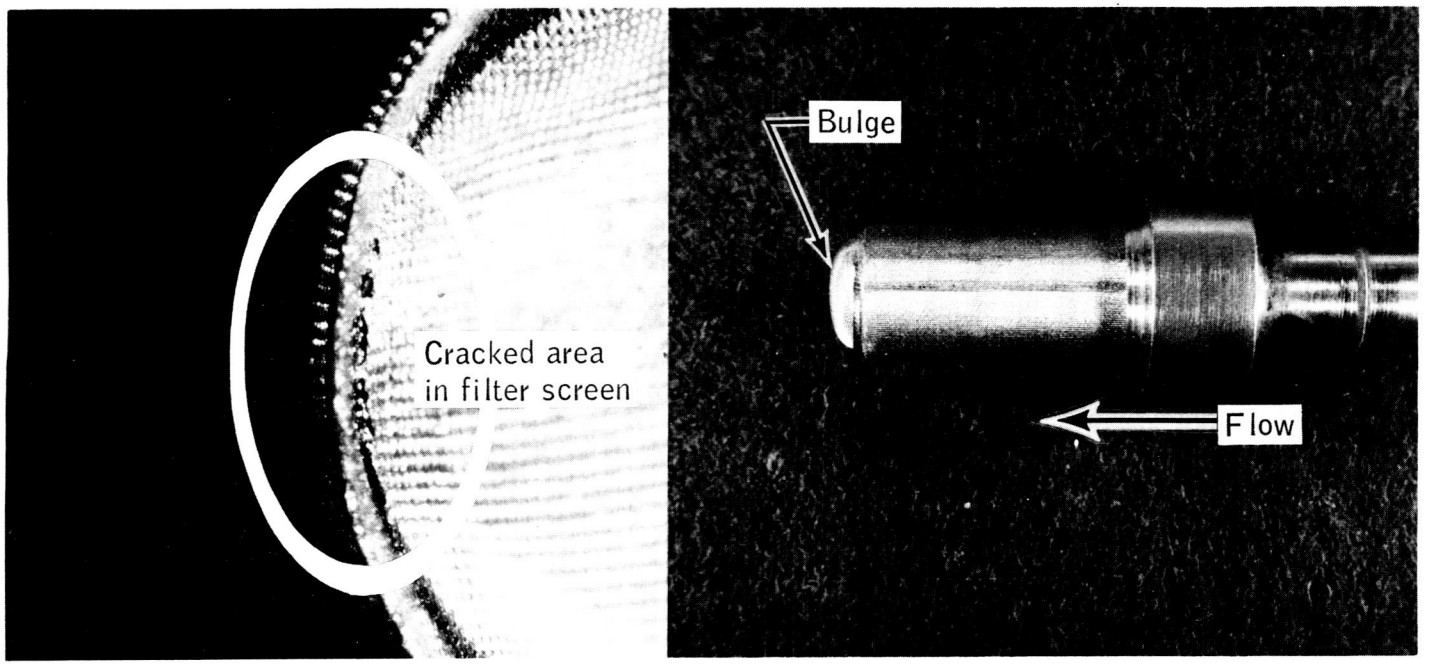


Figure 2. - Helium pressurization system configuration.



(a) Front view showing cracked edge.

(b) Side view showing deformed end.

Figure 3.- Reaction control system regulator filter.

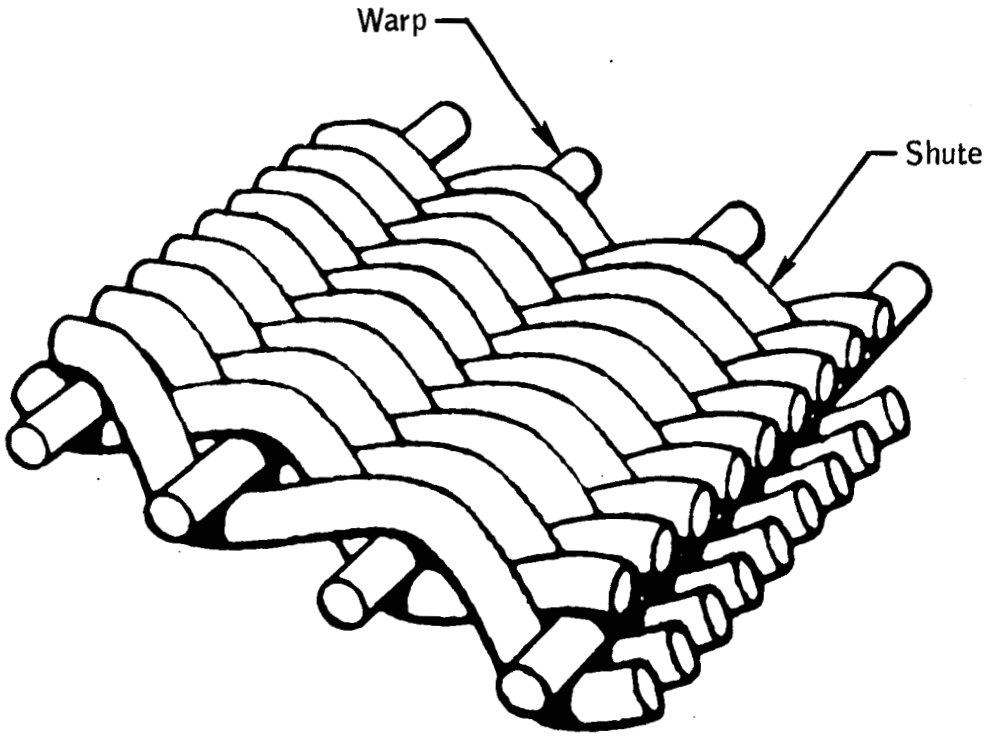


Figure 4.- Weave pattern of filter.

When the first valve opens, a pressure surge propagates from the valve to the inlet side of the two series regulators. The surge is driven by the helium tank pressure of 4150 psi. If the second valve opening is delayed by 2 milliseconds, a pressure surge also propagates from the second valve to the inlet of the regulators in that leg, but the driving pressure will be only 2500 psi since the flow limiting orifice in the helium tank outlet line will not pass enough helium in 2 milliseconds to maintain the valve inlet manifold pressure. The pressure surges will affect the filters in both regulator legs of each pressurization system, but the filter receiving the surge with the larger driving pressure will be most affected.

Inlet filters on a lunar module system were not bulged when examined after a special activation test. The lunar module regulator inlet filters are subjected to lesser pressure surges because of a 0.028-inch flow-limiting orifice in each regulator leg between the pyrotechnic isolation valve and the series regulators.

Yielding of the filter cap with some wire breakage, as seen in the Apollo 16 filters, may occur and result in degradation of the filter to a 100-micron rating. In any event, a 40-micron filter on the outlet of the pyrotechnic isolation valve provides protection to the system.

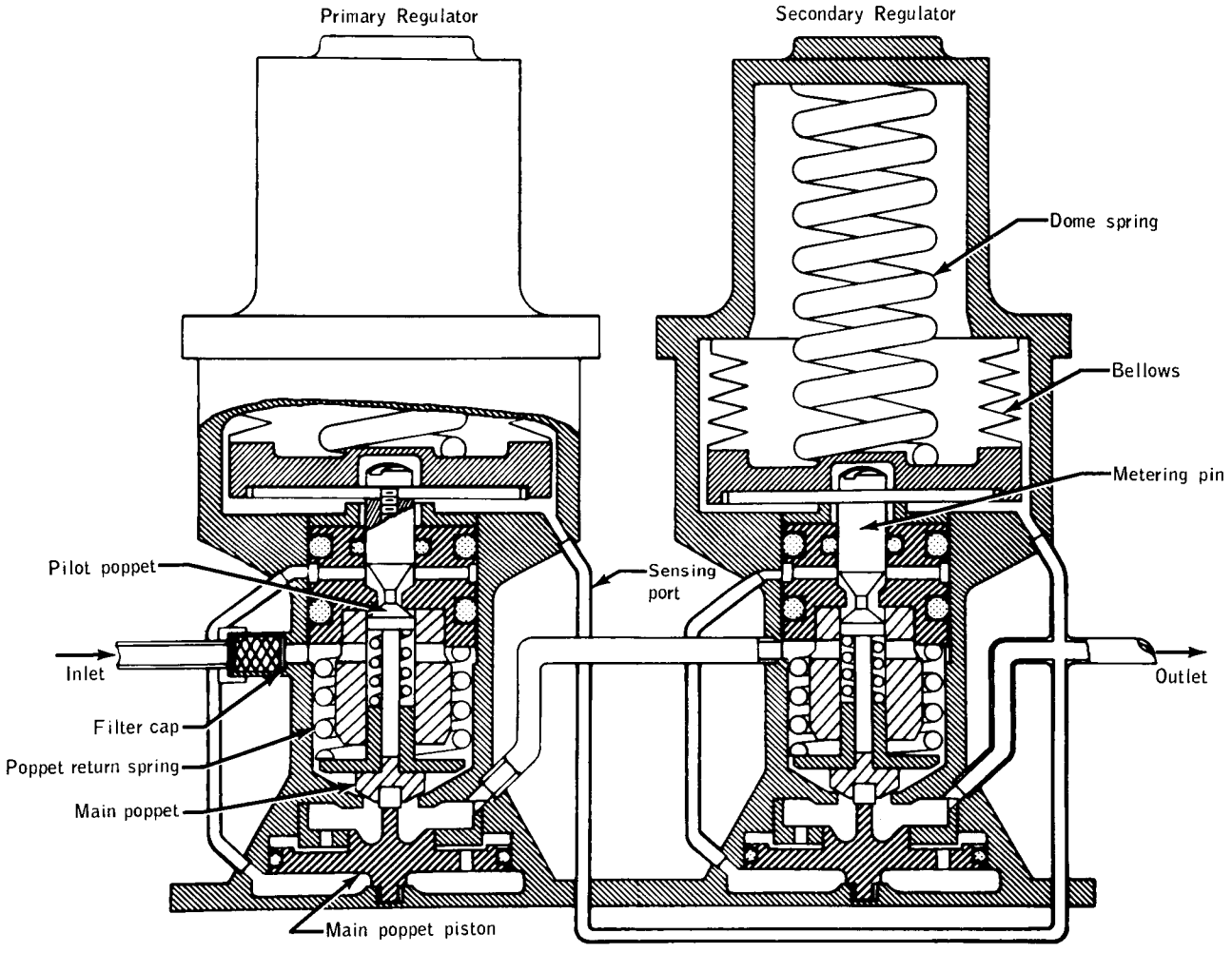
If the entire filter and cap should break, the end cap would move into the regulator and most likely be trapped within the regulator body by the poppet return spring (fig. 5). If somehow the screen jammed in the main poppet seat, the secondary regulator would control the pressure.

CONCLUSIONS

The filter element end caps were bulged by the helium pressure surge during activation. Some end caps may bulge and also some wire separation may occur during future command module reaction control system activations; however, system performance should not be affected.

CORRECTIVE ACTION

The reaction control system design is acceptable and no change in hardware, system, or activation procedures is required.



Note: Normal pressurized configuration:
Primary main and pilot poppets closed
Secondary main poppet closed
Pilot poppet-open responding to pressure demand

Figure 5.- Cross-section of reaction control regulator.